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(54) **METHOD FOR PICKING UP AN ARTICLE USING A ROBOT ARM AND ASSOCIATED SYSTEM**

(71) Applicant: **Simon Melikian**, Westlake, OH (US)

(72) Inventor: **Simon Melikian**, Westlake, OH (US)

(73) Assignee: **RECOGNITION ROBOTICS, INC.**, Elyria, OH (US)

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     B25J 9/08   (2006.01)
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(52) **U.S. Cl.**
     CPC *B25J 9/1664* (2013.01); *B25J 9/08* (2013.01); *B25J 19/023* (2013.01); *B23Q 3/15546* (2013.01); *G05B 2219/36362* (2013.01); *G05B 2219/40284* (2013.01); *G05B 2219/50276* (2013.01); *Y10S 901/02* (2013.01); *Y10S 901/47* (2013.01)

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     CPC A61B 2019/2234; B23Q 3/15546; G05B 2219/32114; G05B 2219/37572; G05B 2219/39393; G05B 2219/40564; G05B 2219/31095; G05B 2219/36362; G05B 2219/50276; G05B 2219/50252; G05B

2219/50242; G05B 2219/40284; G06T 2207/30164; G06T 7/0004; G06T 7/0042; B85J 9/1664; B85J 19/023; B85J 9/08; Y10S 901/02; Y10S 901/47
USPC 700/259; 901/30, 41
See application file for complete search history.

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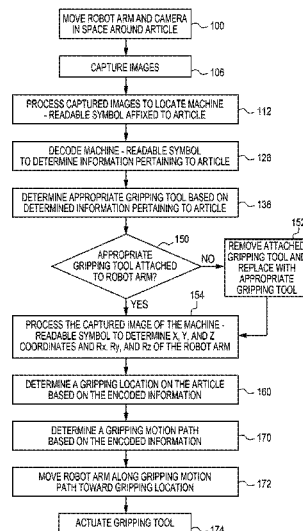|				
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Primary Examiner — Jason Holloway
(74) *Attorney, Agent, or Firm* — Rankin, Hill & Clark LLP

(57) **ABSTRACT**

A method for picking up an article using a robot arm includes capturing images with a camera and processing the captured images to locate a machine-readable symbol affixed to the article. The machine-readable symbol includes an orientation pattern and encoded information pertaining to the article. The orientation pattern provides information to determine x, y, and z coordinates and Rx, Ry and Rz of a gripping tool attached to the robot arm. The encoded information provides information to determine the appropriate gripping tool, gripping location and gripping motion path.
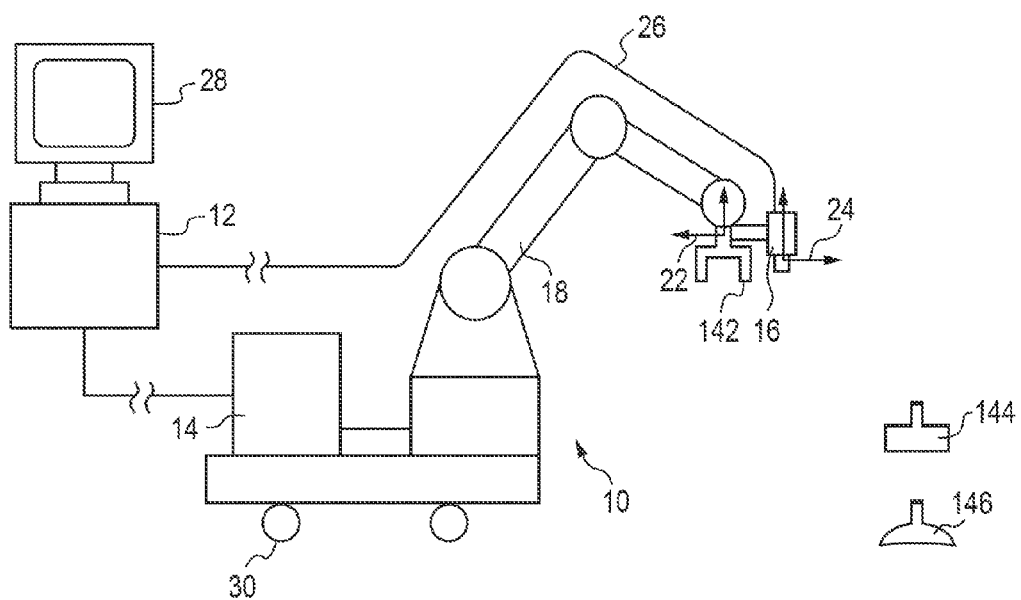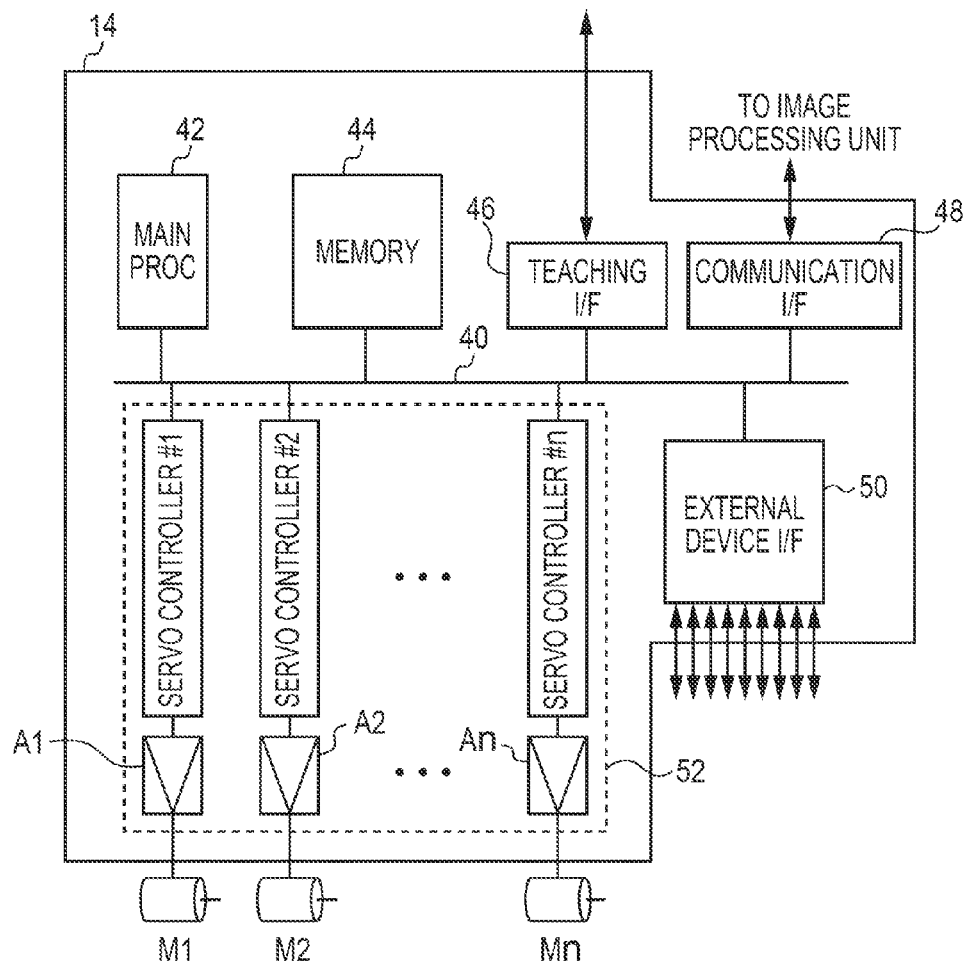
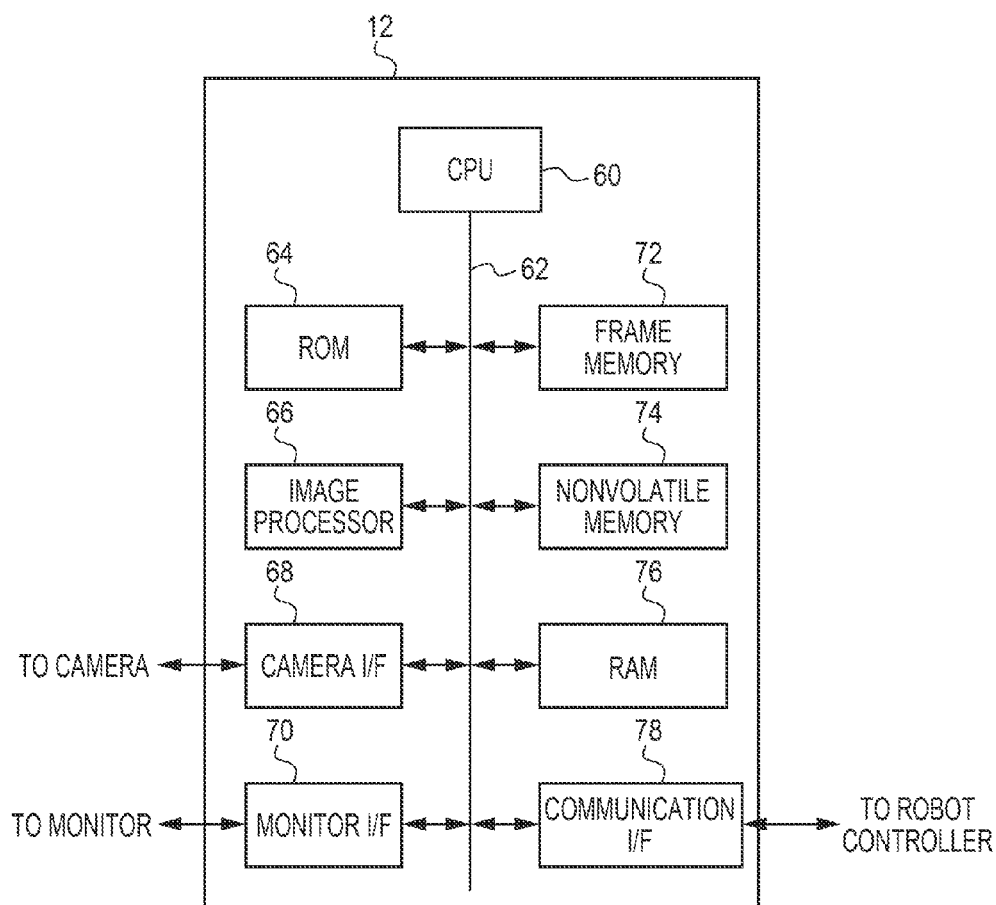**17 Claims, 6 Drawing Sheets**
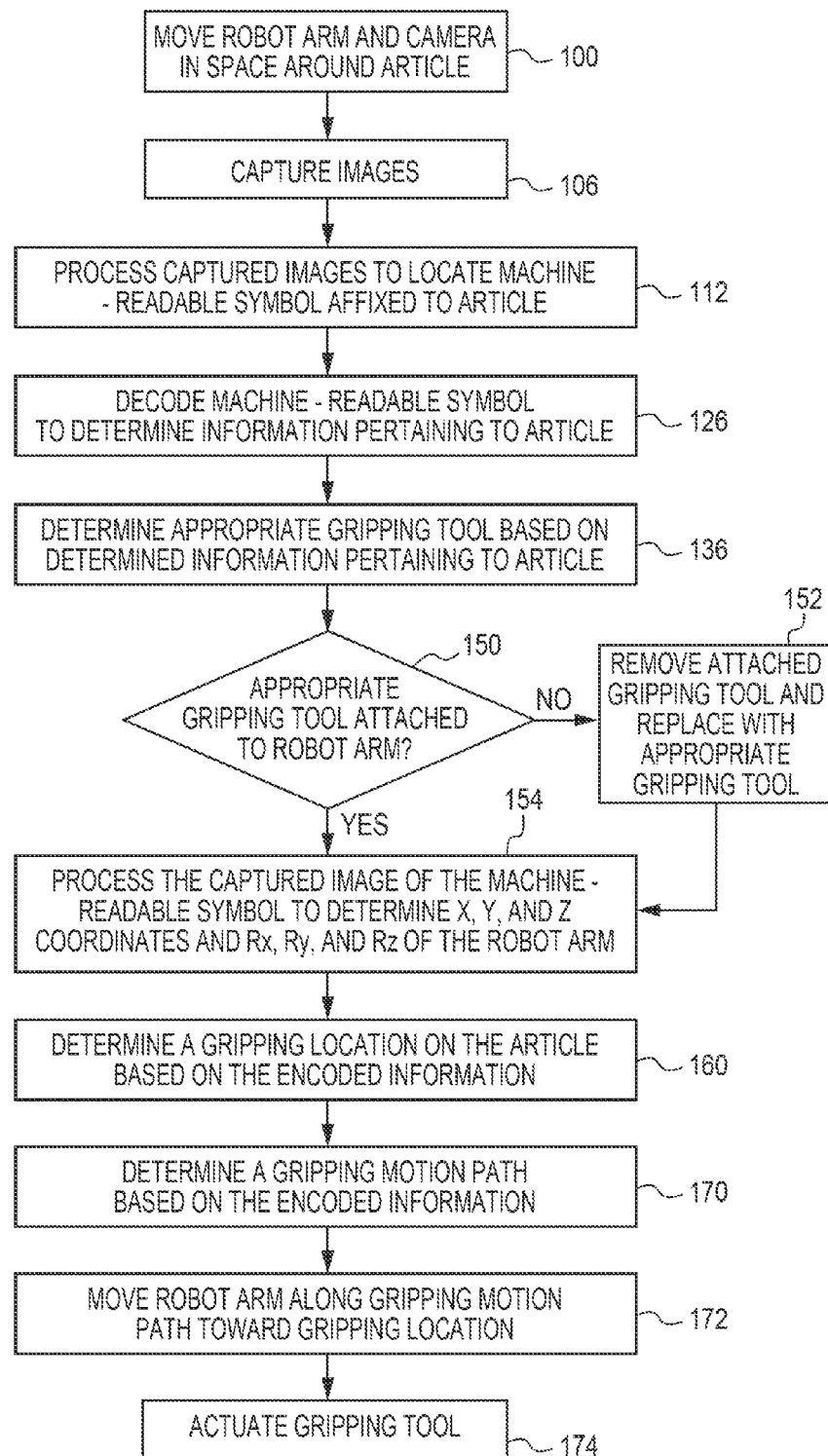
FIG. 1

FIG. 2

FIG. 3

MOVE ROBOT ARM AND CAMERA IN SPACE AROUND ARTICLE — 100

CAPTURE IMAGES — 106

PROCESS CAPTURED IMAGES TO LOCATE MACHINE - READABLE SYMBOL AFFIXED TO ARTICLE — 112

DECODE MACHINE - READABLE SYMBOL TO DETERMINE INFORMATION PERTAINING TO ARTICLE — 126

DETERMINE APPROPRIATE GRIPPING TOOL BASED ON DETERMINED INFORMATION PERTAINING TO ARTICLE — 136

APPROPRIATE GRIPPING TOOL ATTACHED TO ROBOT ARM? — 150

NO → REMOVE ATTACHED GRIPPING TOOL AND REPLACE WITH APPROPRIATE GRIPPING TOOL — 152

YES

PROCESS THE CAPTURED IMAGE OF THE MACHINE - READABLE SYMBOL TO DETERMINE X, Y, AND Z COORDINATES AND Rx, Ry, AND Rz OF THE ROBOT ARM — 154

DETERMINE A GRIPPING LOCATION ON THE ARTICLE BASED ON THE ENCODED INFORMATION — 160

DETERMINE A GRIPPING MOTION PATH BASED ON THE ENCODED INFORMATION — 170

MOVE ROBOT ARM ALONG GRIPPING MOTION PATH TOWARD GRIPPING LOCATION — 172

ACTUATE GRIPPING TOOL — 174

FIG. 4

102

162

110

128

FIG. 5

104

164

110

FIG. 6

130

122

0123456789

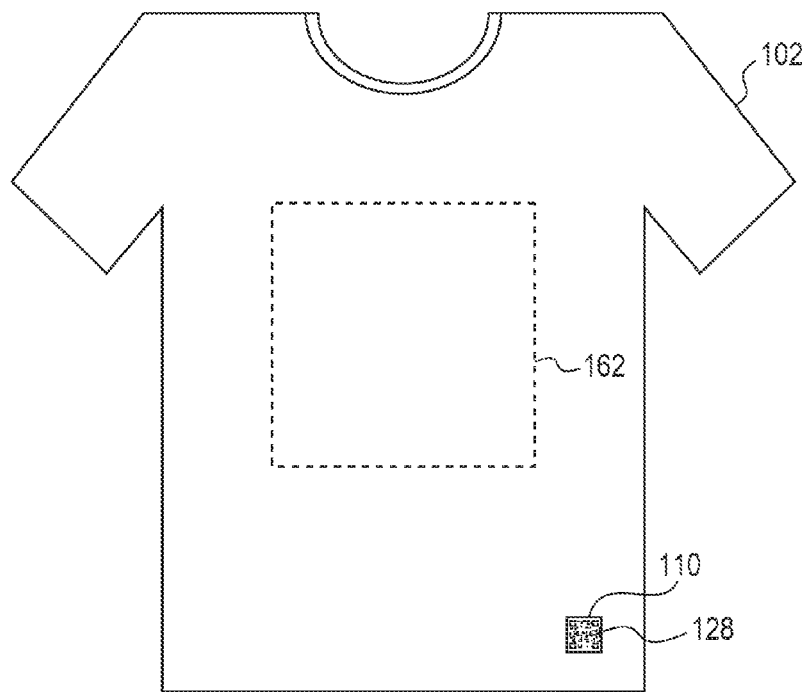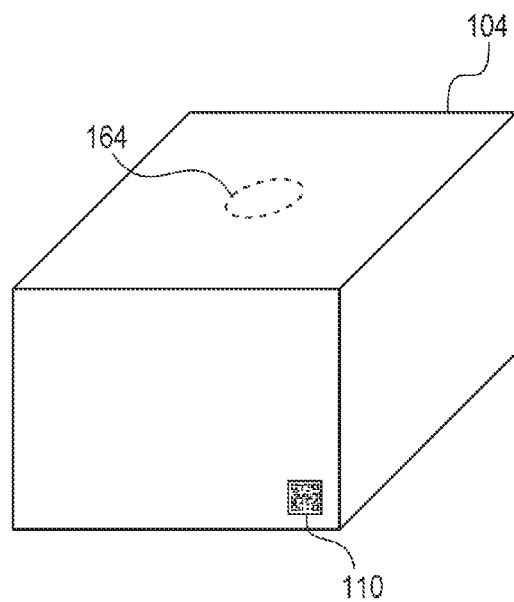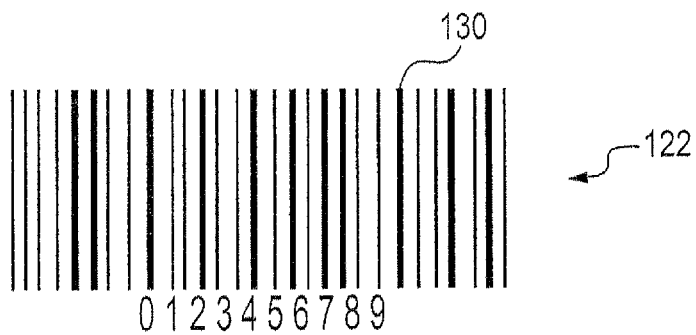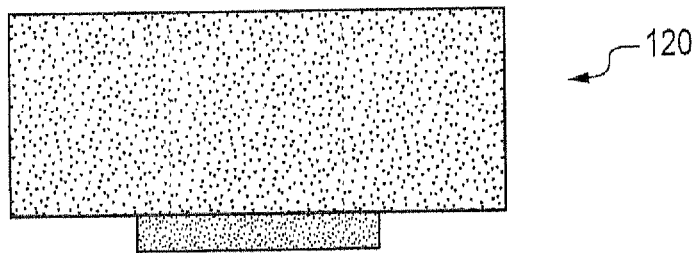## FIG. 7 A

120

FIG. 7 B

METHOD FOR PICKING UP AN ARTICLE USING A ROBOT ARM AND ASSOCIATED SYSTEM

BACKGROUND

Robots have been used to pick up articles, for example on manufacturing assembly lines. Typically the article is presented to the robot in a particular orientation so that the movement of the robot arm to pick up the article can be confined to a particular motion path. Even when the robot arm is associated with a computer vision system, the article that is to be picked up is still typically presented to the robot in a particular orientation. Many more problems are presented when the robot arm is used to grip an article in unconstrained environment, i.e., in an environment where the article is not presented to the robot in any particular orientation. In such non-constrained environment the robot does not "know" the particular motion path to grip the article, nor does it know any information with regard to the orientation of the article.

SUMMARY

In view of the foregoing, a method for picking up an article using a robot arm is disclosed. The method includes moving the robot arm having a camera mounted thereto in a space around the article. The method further includes capturing images with the camera and processing the captured images with computer software to locate a machine-readable symbol affixed to the article. The machine-readable symbol includes an orientation pattern for determining an orientation of the machine-readable symbol and encoded information pertaining to the article. The method further includes decoding the machine-readable symbol to determine information pertaining to the article and determining an appropriate gripping tool from a plurality of available gripping tools based on the determined information pertaining to the article. The method further includes determining whether the appropriate gripping tool is attached to the robot arm. If it is determined that the appropriate gripping tool is not attached to the robot arm, the method includes removing any gripping tool attached to the robot arm, and attaching the appropriate gripping tool. The method also includes processing at least one captured image that includes the machine-readable symbol to determine x, y, and z coordinates and Rx, Ry and Rz of the appropriate gripping tool attached to the robot arm with respect to the machine-readable symbol. The method further includes determining a gripping location on the article based on the determined information pertaining to the article, determining a gripping motion path in which the robot arm moves to grip the article with the gripping tool based on the determined information pertaining to the article, moving the robot arm along the gripping motion path toward the gripping location, and actuating the gripping tool to grip the article at the gripping location.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic depiction of a robot having a robot arm and an image processing unit in communication with the robot.

FIG. **2** is a schematic depiction of the components of a robot controller for the robot depicted in FIG. **1**.

FIG. **3** is a schematic depiction of the components of the image processing unit depicted in FIG. **1**.

FIG. **4** is a flow diagram depicting a method for picking up an article using the robot arm.

FIGS. **5** and **6** depict articles that are to be picked up by the robot arm.

FIGS. **7A** and **7B** depict steps involved in processing an image of a machine-readable symbol to teach the machine-readable symbol to the robot depicted in FIG. **1**.

DETAILED DESCRIPTION

FIG. **1** depicts a robot **10** in communication with an image processing unit **12**. The robot **10** includes a robot controller **14**, which can be conventional, and a camera **16**, which can be a conventional CCD camera. The robot **10** includes a robot arm **18** that is moveable in multiple directions and in multiple axes. The camera **16** is mounted to a distal end portion of the robot arm **18**. A relative relationship between a coordinate system **22** at the distal end portion of the robot arm **18** and a reference coordinate system **24** for the camera **16** is set. An image captured by the camera **16** is output to the image processing unit **12** via a communication line **26**, which can be wireless. The image processing unit **12** also includes a monitor **28** for display of the captured image. The robot **10** can further include wheels **30** (or similar device) so that the robot can travel across a surface.

FIG. **2** schematically depicts the robot controller **14**, which can be the same in construction as a conventional robot controller. A bus **40** connects a main processor **42**, a memory **44** including RAM, ROM and non-volatile memory, a teaching interface **46**, an image processing unit interface **48**, an external device interface **50**, and a servo control unit **52**. A system program for performing basic functions of the robot **10** and robot controller **14** is stored in the ROM of the memory **44**. A program for robot operation that varies depending on application is taught beforehand and is stored in the non-volatile memory of the memory **44**, together with relevant pre-set data. The program for robot operation that varies depending on application can be taught through the teaching interface **46**. The servo control unit **52** includes servo controllers #1 to #n (where n indicates the total number of robot axes). Each of the servo controllers includes a processor and memory arranged to carry out control for a corresponding axis servo motor M1-Mn. Outputs of the servo controllers are delivered through servo amplifiers A1-An to the axis servo motors M1-Mn, which are provided with position/speed detectors for individually detecting the position, speed of the servo motors so that the position/speed of the servo motors is fed back to the servo controllers. External devices such as actuators and sensors of peripheral equipment connect to the robot controller **14** through the external device interface **50**.

FIG. **3** schematically depicts the image processing unit **12**, which is connected to the robot controller **14** through the image processing unit interface **48** (FIG. **2**). A processor **60** connects through a bus **62** to a ROM **64** for storing a system program executed by the processor **60**, an image processor **66**, a camera interface **68**, a monitor interface **70**, a frame memory **72**, a non-volatile memory **74**, a RAM **76** used for temporal data storage, and a robot controller interface **78**. The camera interface **68** allows the camera **16** (FIG. **1**) to connect with the image processing unit **12**. The monitor interface **70** allows the image processing unit **12** to connect with the monitor **28** (FIG. **1**). The robot controller interface **78** allows the image processing unit **12** to connect with the robot controller **14**.

FIG. **4** depicts a method for picking up an article using a robot arm, such as the robot arm **18** depicted in FIG. **1**. FIG. **4** depicts the steps of the method for picking up an article in a particle order. It should be understood that the order in which the steps are presented in FIG. **4** and described below could be

changed, and that the steps need not be performed in any particular temporal order unless it is particularly described as such. Moreover, some steps may be performed at the same time as others.

The robot arm **18** (FIG. **1**) having the camera **16** (FIG. **1**) mounted thereto is moved in a space around an article that is to be picked up (step **100**). The article to be picked up can be an article in commerce, e.g., a T-shirt **102** in FIG. **5**, or an article that can be used in the manufacture of articles of commerce, such as components of an automobile. The robot **10** can be moved to an area around the article by propelling the wheels **30** using motors (not shown). The control of the movement of the robot **10** to a particular location and driving the wheels **30** can be performed by GPS or other control systems. Examples of articles that can be picked up by the robot include a t-shirt **102**, which is shown in FIG. **5**, and a box **104**, which is shown in FIG. **6**. These are just two non-limiting examples of articles that could be picked up using the robot **10**.

As the robot arm **18** is moved in a space around the article **102**, **104** that is to be picked up, the camera **16** captures images (step **106**), which are sent over the communication line **26** to the image processing unit **12**. With reference to FIGS. **5** and **6**, the articles **102**, **104** that are to be picked up by the robot **10** each include a machine-readable symbol **110** affixed to the article. The articles **102**, **104** are positioned so that the machine-readable symbol **110** is visible in a possible field of view for the camera **16** as the robot arm **18** moves in the space around the article. However, the orientation of article **102**, **104** need not be limited to any particular orientation other than to require that the machine-readable symbol **110** be in the possible field of view for the camera as the robot arm **18** moves in the space around the article.

The captured images from the camera **16** are processed in the image processor **66** (FIG. **3**), which includes computer software, to locate the machine-readable symbol **110** affixed to the article **102**, **104** (step **112**). For the articles illustrated in FIGS. **5** and **6**, the machine-readable symbol is a 2D (or matrix) bar code, which is known as a QR code. Other machine-readable symbols such as 1D bar codes, which is shown in FIG. **7a**, can also be used as the machine-readable symbol. Whether the machine-readable symbol is a 1D bar code or a 2D bar code or another type of machine-readable symbol, the machine-readable symbol is an optical machine-readable representation of data or information relating to the article to which it is attached and includes an orientation pattern for determining an orientation of the machine-readable symbol and encoded information pertaining to the article to which the machine-readable symbol affixed. The machine-readable symbol is decoded by the image processing unit **12** in a manner that will be described in more detail below.

Processing the captured images with computer software to locate the machine-readable symbol **110** affixed to the article **102**, **104** can be performed by comparing a learned image **120**, an example of which is shown in FIG. **7b**, to a target image, which is located in the captured images that were captured by the camera **16** in step **106**. The learned image **120** depicted in FIG. **7b** represents a machine-readable symbol such as a UPC code **122** that is shown in FIG. **7A**. The learned image **120** has a perimeter the same in size and shape as the UPC code **122**. The learned image **120** is an image of the UPC code that is eroded or dilated to merge indicia, such as the bars making up the UPC code, which results in the learned image **120** being a structure having an outline or perimeter that is the same as the UPC code. A similar type of process could be performed on a QR code where the learned image would be an image of the QR code that is eroded or dilated to merge indicia

making up the QR code, such as the cells in the QR code, such that the learned image is a structure having an outline or perimeter that is the same as the QR code, i.e., a one inch square. The learned image **120** is then taught to the image processor **66** in the image processing unit **12**.

The images that are captured by the camera (step **106**) are continued to be processed until there is a match between a target image in one of the images that was captured by the camera **16** and a learned image, such as the learned image **120** in FIG. **7b**. Since the machine-readable symbols can each be unique, the image processor **66** does not learn each unique machine-readable symbol, e.g., the image processor does not learn each unique QR code or each unique UPC code that is to be affixed on an article to be picked up. Instead, the image processor **66** is programmed to recognize images that are more general than the specific machine-readable symbol **110** that is affixed to the article **102**, **104** that is to be picked up. As such, the learned image **120** that is eroded or dilated is taught to the image processing unit **12**. A match between the target image and the learned image can be determined using systems described in U.S. Pat. Nos. 7,831,098 and 8,150,165, which are commonly owned.

Processing the captured images with computer software to locate the machine-readable symbol **110** affixed to the article **102**, **104** can also be performed in other manners. The machine-readable symbol **110** depicted in FIGS. **5** and **6** is surrounded by an optical quiet zone **128**. The UPC code **122** depicted in FIG. **7a** is also surrounded by an optical quiet zone **130**. The image processor **66** can include computer software to locate the machine-readable symbol affixed to the article by comparing a learned image, which represents the optical quiet zone of the machine-readable symbol, to a respective target image, which is located in the captured images from step **106**, to identify a match between the learned image and the target image. The optical quiet zone surrounding QR codes, for example, is the same for each QR code no matter the encoded information within the QR code. The same holds true for a UPC code. As such, the quiet zone of each of these codes could be taught to the image processing unit **12** and the image processor **66** can be programmed to recognize the appropriate optical quiet zone. A match between the target image and the learned image can be determined using systems described in U.S. Pat. Nos. 7,831,098 and 8,150,165.

After the machine-readable symbol **110** has been located on the article **102**, **104**, the image processor **66** (FIG. **3**) decodes the machine-readable symbol to determine information pertaining to the article (step **126**). The image processor **66** can be programmed with the appropriate known 1D and 2D barcode decoding software. The information that is encoded in the machine-readable symbol can include information as to the appropriate gripping tool that should be used to grip the article. The encoded information on the machine-readable symbol could also include the gripping location on the article, the gripping motion path in which the robot arm **18** moves to grip the article with the gripping tool, and the pressure applied by the gripping tool on the article. The encoded information in the machine-readable symbol could also include the weight of the article, the size of the article, and the material type of the article as well as other information commonly found in QR codes and UPC codes. Again, QR codes and UPC bar codes are only two examples of machine-readable symbols that could be employed. It is quite likely that another type of optically machine-readable symbol that can encode the information shown above (or direct the image processing unit to appropriate database to locate the information) would be employed. Other known matrix-type

machine readable codes that are in use in commerce, such as matrix codes similar to those used by United Parcel Service (UPS), could also be used.

The main processor **42** on the robot controller **14** or the processor **60** on the image processing unit **12** determines the appropriate gripping tool based on the determined information pertaining to the article that was decoded from the machine-readable symbol in step **126** (step **136**). A plurality of gripping tools **142**, **144**, **146** can attach to the distal end portion of the robot arm **18**. FIG. **1** depicts a gripper **142**, a magnet **144**, and a suction cup **146** as the gripping tools. Other gripping tools could also be used. The appropriate gripping tool to be used to pick up the article is based on the information determined in step **126**. In step **126**, the image processing unit **12** can access or include a database that stores article weight information, article size information and article material type information for each of the articles that are to be picked up. This information pertaining to the article is encoded in the machine-readable symbol. For example, the machine-readable symbol **110** affixed to the T-shirt **102** in FIG. **5** might include information to indicate that the T-shirt weighs about 1 pound, that the T-shirt is generally rectangular having a height of 2 feet and a width of 1½ feet, and that T-shirt is made from cotton. Based on this information, the appropriate gripping tool can be chosen. An algorithm can be programmed into the main processor **42** of the robot controller **14** or the processor **60** of the image processing unit **12** that associates the characteristics of the article to be picked up, i.e. weight, size and material type information, to the appropriate gripping tool. For example, a lightweight article such as a T-shirt made of a flexible material could be gripped with the gripper **142**. Alternatively, if the material type was a magnetic material, then the magnet **144** would be the appropriate gripping tool. If the weight of the object and the material type allowed for it, then the section cup **146** could be the appropriate gripping tool.

The determination of the appropriate gripping tool can be based on at least one of the determined article weight information, the determined article size information and the determined article material type and information from step **126**. For example, if the material type information indicates that the material of the article to be picked up is made of glass, then the appropriate gripping tool can be assigned as the suction cup **146**. The step of determining the appropriate gripping tool can also be based on each of the determined article weight information, the determined article size information and the determined article material type information. In other words, the weight, the size, and the material type may all be taken into account when determining the appropriate gripping tool. Also, the encoded information within the machine-readable symbol can also provide the robot controller **14** the appropriate gripping tool. In other words, part of the information that is encoded within the machine-readable symbol could indicate that the particular article is to be picked up, for example, by the gripper **142**.

Each of the gripping tools **142**, **144**, **146** that attach to the robot arm **18** can include some sort of sensing and identification device (not shown). This device communicates with the main processor **42** of the robot controller **14** through the external device interface **50** (FIG. **2**) to indicate the type of tool attached to the robot arm **18**. The robot controller **14** can then determine whether the appropriate gripping tool is attached to the robot arm **18** to grip the particular article (step **150**). If at step **150** it is determined that the appropriate gripping tool is not attached to the robot arm **18**, then the inappropriate gripping tool is removed and the appropriate gripping tool is then attached with the robot arm (step **152**).

The machine-readable symbol does not only provide information to the robot controller **14** to allow the robot controller to determine the appropriate gripping tool, gripping motion, and gripping location of the article. The machine-readable symbol also aids in aligning the robot arm **18** with respect to the article that is to be picked up. The image processor **66** processes the captured image of the machine-readable symbol, which can be the same image that was read by the QR code reader or barcode reader at step **126**, to determine x, y and z coordinates and Rx, Ry, and Rz of the appropriate gripping tool attached to the robot arm **18**. As mentioned above, the coordinate system **22** at the distal end portion of the robot arm **18** and the reference coordinate system **24** for the camera **16** is set. The image processor **66** can use a learned image, such as the learned image **120** depicted in FIG. **7b**, to determine the reference frame for the robot arm **18** with respect to the article that is to be picked up. The image processor **66** can be programmed to determine an amount of translation, rotation, and scaling needed to transform a learned image, which is the same in size and shape as the machine-readable symbol, such that the learned image overlaps the image of the machine-readable symbol and the image that was captured by the camera **16**. Such a recognition program is more fully described in U.S. Pat. No. 8,150,165. With the robot arm **18** appropriately aligned with the article to be picked up, the problem with orienting the article with respect to the robot arm is now overcome.

Determining the x, y, and z coordinates and Rx, Ry, and Rz of the robot arm **18** can also be performed by comparing the quiet zone of the machine-readable image and the target image as compared to learned quiet zones of machine-readable images similar to that shown in the target image. In other words, a quiet zone for a QR code could be taught to the image processing unit **12** in a manner more fully described in U.S. Pat. No. 8,150,165 and for an article to be picked up that includes the QR code, the quiet zone from the learned image could be compared to the quiet zone and the target image to determine x, y, and z coordinates and Rx, Ry and Rz of the robot arm. Moreover, indicia within the machine-readable symbol itself could be used to align the robot arm with respect to the article. For example, matrix codes used by UPS include indicia to determine the orientation of the machine-readable symbol. The image processor **66** can be programmed to determine an amount of translation, rotation, and scaling needed to transform the captured image that includes the machine-readable symbol to align the robot arm.

The main processor **42** on the robot controller **14** or the processor **60** in the image processing unit **12** can be used to determine a gripping location on the article **102**, **104** based on information encoded in the machine-readable symbol **110** (step **160**). For example, the T-shirt **102** depicted in FIG. **5** shows a gripping location as a square region **162** on the T-shirt **102**. The box **104** depicted in FIG. **6** depicts a circular region **164** as the gripping location. The location of the machine-readable symbol **110** with respect to the gripping location **162**, **164** can be set. The x, y and z offset of the center (or other location) of the machine-readable symbol **110** and the center (or other location) of the gripping location **162**, **164** can be set and encoded in the machine-readable symbol. In such a situation the machine-readable symbol would be affixed in the same location when it is attached to similar articles, e.g., the machine-readable symbol would be attached within a region on the lower right front corner of each similar T-shirt **102**. As such, when the robot arm is properly aligned with the machine-readable symbol **110**, the robot controller **14** can then move the robot arm **18** to the appropriate gripping location based on information decoded from the machine-read-

able symbol. With the machine-readable symbol **110** affixed to the article **102, 104** at a specified location with respect to the gripping location and the encoded information in the machine-readable symbol **110** including information for determining the gripping location, the robot arm can be moved to the appropriate place to grip the article.

The main processor **42** on the robot controller **14** or the processor **60** on the image processing unit **12** can also determine a gripping motion path for the robot arm **18** (step **170**). As discussed above, article weight information, article size information and article material type information can be encoded in the machine-readable symbol **110**. Just as this information can be used to determine the appropriate gripping tool **142, 144, 146**, this information can also be used to determine the gripping motion path in which the robot arm **18** moves to grip the article **102, 104** with the gripping tool. The motion used by the robot arm **18** to pick up the T-shirt **102** in FIG. **5** would differ from the motion that the robot arm would take to pick up the box **104** depicted in FIG. **6**. Algorithms can be programmed into the main processor **42** on the robot controller **14** so that the robot arm **18** chooses the appropriate motion path to pick up the desired article. The robot arm **18** is then moved along the gripping motion path that was determined in step **170** (step **172**). The gripping tool is then actuated (step **174**). As such, the article is gripped and can be picked up by the robot arm **18**.

It will be appreciated that various of the above-disclosed and other features and functions, or alternatives or varieties thereof, may be desirably combined into many other different systems or applications. Also that various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

The invention claimed is:

1. A method for picking up an article using a robot arm, the method comprising:

moving the robot arm having a camera mounted thereto in a space around the article;

capturing images with the camera;

processing the captured images with computer software to locate a machine-readable symbol affixed to the article, wherein the machine-readable symbol includes an orientation pattern for determining an orientation of the machine-readable symbol and encoded information pertaining to the article;

decoding the machine-readable symbol to determine information pertaining to the article;

determining an appropriate gripping tool from a plurality of available gripping tools based on the determined information pertaining to the article;

determining with computer software whether the appropriate gripping tool is attached to the robot arm;

if it is determined that the appropriate gripping tool is not attached to the robot arm, then removing any gripping tool attached to the robot arm, and attaching the appropriate gripping tool;

processing the at least one captured image that includes the machine-readable symbol to determine x, y, and z coordinates and Rx, Ry, and Rz of the appropriate gripping tool attached to the robot arm with respect to the machine-readable symbol;

determining a gripping location on the article based on the determined information pertaining to the article;

determining a gripping motion path in which the robot arm moves to grip the article with the gripping tool based on the determined information pertaining to the article;

moving the robot arm along the gripping motion path toward the gripping location; and

actuating the gripping tool to grip the article at the gripping location.

2. The method of claim **1**, wherein the step of capturing images with the camera is performed using a non-structured light source.

3. The method of claim **1**, wherein the step of processing the captured images with computer software to locate a machine-readable symbol affixed to the article includes comparing a learned image, which represents the machine-readable symbol, to a respective target image, which is located in the captured images, to identify a match between the learned image and the target image.

4. The method of claim **3**, wherein the learned image has a perimeter the same in size and shape as the machine-readable code.

5. The method of claim **3**, wherein the machine-readable symbol is a 1D or a 2D barcode.

6. The method of claim **5**, wherein the learned image is an image of the machine-readable symbol that is eroded or dilated to merge indicia making up the machine-readable symbol such that the learned image is a structure having an outline or perimeter that is the same as the machine-readable symbol.

7. The method of claim **1**, wherein the machine-readable symbol is a 1D or a 2D barcode and the orientation pattern is an optical quiet zone surrounding the 1D or the 2D barcode, wherein the step of processing the captured images with computer software to locate a machine-readable symbol affixed to the article includes comparing a learned image, which represents the optical quiet zone of the machine-readable symbol, to a respective target image, which is located in the captured images, to identify a match between the learned image and the target image.

8. The method of claim **1**, wherein the step of decoding the encoded information in the machine-readable symbol includes accessing a database to determine article weight information, article size information and article material type information.

9. The method of claim **8**, wherein the step of determining the appropriate gripping tool includes determining the appropriate gripping tool based on at least one of the determined article weight information, the determined article size information and the determined article material type information.

10. The method of claim **8**, wherein the step of determining the appropriate gripping tool includes determining the appropriate gripping tool based on each of the determined article weight information, the determined article size information and the determined article material type information.

11. The method of claim **8**, wherein the step of determining a gripping location on the article further includes determining the gripping location based on the determined article size information and knowing a location of the machine-readable symbol on the article.

12. The method of claim **1**, wherein the machine-readable code includes a gripping tool code associated with the appropriate gripping tool for gripping the article.

13. The method of claim **1**, wherein the machine-readable code includes a gripping location code associated with the gripping location for the article.

14. The method of claim **1**, wherein the machine-readable symbol is affixed to the article at a specified location and the encoded information in the machine-readable symbol includes information for determining the gripping location based on the encoded information and the specified location.

15. The method of claim **1**, wherein the step of processing the at least one captured image that includes the machine-readable symbol to determine x, y, and z coordinates and Rx, Ry, and Rz of the appropriate gripping tool further includes determining an amount of translation, rotation and scaling needed to transform a learned image, which is the same in size and shape as the machine-readable symbol, such that the learned image overlaps the machine-readable symbol in the at least one captured image that includes the machine-readable symbol.

16. The method of claim **15**, wherein the machine-readable symbol is a 1D or a 2D barcode.

17. The method of claim **16**, wherein the learned image is an image of the machine-readable symbol that is eroded or dilated to merge indicia making up the machine-readable symbol such that the learned image is a structure having an outline or perimeter that is the same as the machine-readable symbol.

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